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Java-to-Database Connectivity Server

Abstract:

A Java TM -to-Database Connectivity Server monitors client communications, accesses a database such as a Sybase relational database, upon client command establishes a connection to the database, accesses requested data from the database, manipulates the data, and relays the data to the client. The Java TM -to-Database Connectivity Server is programmed in the Java TM programming language to facilitate communications with Java TM clients using Java TM sockets. The Java TM -to-Database Connectivity Server includes an Applications Programmer Interface (API) on the server side of a client/server interface and implementation of System Query Language (SQL) queries on the client side. The Java TM -to-Database Connectivity Server supplies an interface between Java TM applications and database servers using an easy-to-use Java TM server Applications Programmer Interface (API) forming a uniform framework for building or integrating database connectivity across organizations and companies globally. A single API supplies connectivity with a database, for example, with Oracle or Sybase database servers. In some embodiments, the Java TM -to-Database Connectivity Server is platform-independent and usable on any platform in any usage model (nomadic, remote access, Internet, and Intranet, for example), and encoded entirely in the Java TM programming language using sockets and multi-threading.

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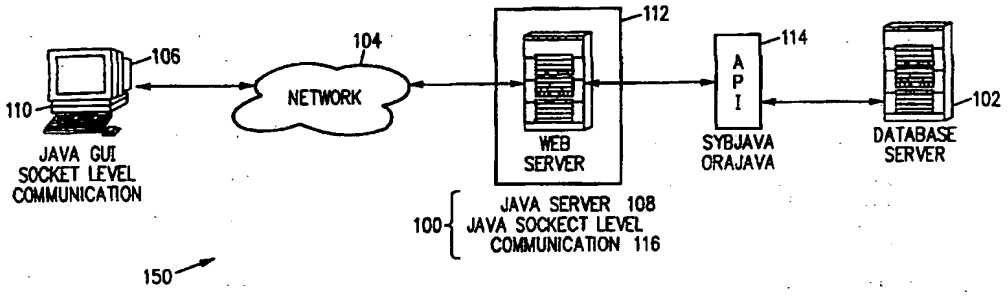

(57) Abstract

A Java™–to–Database Connectivity Server (100) monitors client communications, accesses a database such as a Sybase relational database, upon client command establishes a connection to the database, accesses requested data from the database, manipulates the data, and relays the data to the client. The Java™–to–Database Connectivity Server is programmed in the Java™ programming language to facilitate communications with Java™ client using Java™ sockets. The Java™–to–Database Connectivity Server includes an Applications Programmer Interface (API) (114) on the server side of a client/server interface and implementation of System Query Language (SQL) queries on the client side. The Java™–to–Database Connectivity Server supplies an interface between Java™ applications and database servers (102) using an easy–to–use Java™ server Applications Programmer Interface (API) forming a uniform framework for building or integrating database connectivity across organizations and companies globally. A single API supplies connectivity with a database, for example, with Oracle or Sybase database servers. In some embodiments, the Java™–to–Database Connectivity Server is platform–independent and usable on any platform in any usage model (nomadic, remote access, Internet, and Intranet, for example), and encoded entirely in the Java™ programming language using sockets and multi–threading.

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JAVA-TO-DATABASE CONNECTIVITY SERVER

TECHNICAL FIELD

The present invention relates to information service technology. More specifically, the present invention relates to a system and operating method for connecting an application or applet to a database.

BACKGROUND ART

The Internet is regarded by many as the fastest growing market on Earth. In the 1990s, the number of Internet users has grown exponentially. In June of 1995, an estimated 6.6 million hosts were connected, an increase of nearly 5 million hosts in a mere six months. The current growth rate on the Internet is approximately 75% per year. In June of 1995, the 6.6 million hosts included approximately 120,000 networks and over 27,000 web servers. The number of web servers is doubling approximately every 53 days.

Various technical innovations have proven highly suited to the Internet environment. For example, in 1990 programmers at Sun Microsystems developed a universal programming language, eventually known as "the Java™ programming language". Java, SpecJava, Sun, Sun Microsystems and the Sun Logo are trademarks or registered trademarks of Sun Microsystems, Inc. in the United States and other countries. All SPARC trademarks are used under license and are trademarks of SPARC International, Inc. in the United States and other countries. Products bearing SPARC trademarks are based upon an architecture developed by Sun Microsystems, Inc.

The Java™ programming language resulted from programming efforts intended for coding in the C++ language. The Java™ programming language thus has many commonalities with C++ but is further regarded as a simple, object-oriented, distributed, interpreted yet high performance, robust yet safe, secure, dynamic, architecturally neutral, portable, and multi-threaded language. The Java™ programming language has emerged as the programming language of choice for the Internet. Many large software and hardware companies have licensed the Java™ programming language from Sun Microsystems.

The Java™ programming language is designed to solve several problems in modern programming practice. The Java™ programming language omits many rarely-used, poorly-understood, and confusing features of C++. The omitted features primarily concern operator overloading, multiple inheritance, and extensive automatic coercions. The Java™ programming language includes automatic garbage collection to simplify the task of Java™ programming and avoiding memory allocation and deallocation as in C++. The Java™ programming language eliminates the usage of pointers, instead supporting true arrays having array boundaries which are explicitly checked. The elimination of pointers eliminates vulnerability to many viruses and bugs. The Java™ programming language includes objective-C interfaces and specific exception handlers.

The Java™ programming language has an extensive library of routines for coping easily with TCP/IP protocol (transmission control protocol based on internet protocol) and FTP (file transfer protocol). The Java™ programming language is intended for usage in networked/ distributed environments. The Java™

programming language facilitates the construction of virus-free, tamper-resistant systems. Authentication techniques supported by the Java™ programming language are based on public-key encryption.

One highly advantageous aspect of the Internet is the accessibility of databases to the network. Databases are collections of data configured with a structure for accepting, storing, and providing, on demand, data for single or multiple users. The combination of networks for facilitating information transfer to many users and databases for supplying large amounts of data to the many users are naturally synergistic. Unfortunately, since the Java™ programming language is a relatively new programming language, direct access connections between the Java™ programming language and databases have not yet been developed so that the Java™ programming language cannot directly access a database. Accordingly, an important technical issue is the connectivity of Java™ applications and applets to databases. Connectivity is the capability of a system or device to be attached to other systems or devices without modification. As system development organizations begin to migrate to Java™/ Web-enabled environments, the connectivity of Java™ application and applet connectivity to various databases becomes highly advantageous.

What is needed is a highly efficient, powerful and usable system and operating method for executing database transactions between a Java™ front-end and a standard System Query Language (SQL)-type database.

Although Java™ applications can be programmed to communicate with databases using interfaces such as CGI-BIN, typical object-oriented techniques, and C/C++ solutions, the amount of program code development and interfacing effort using these techniques is substantial and, in some cases, essentially prohibitive.

Therefore, a system and operating method that facilitates interfacing between databases and Java™ applications or applets and minimizes the amount of application code for forming the interface is highly advantageous.

DISCLOSURE OF INVENTION

In accordance with the present invention, a Java™-to-Database Connectivity Server monitors client communications, accesses a database such as a Sybase relational database, upon client command establishes a connection to the database, accesses requested data from the database, manipulates the data, and relays the data to the client. The Java™-to-Database Connectivity Server is programmed in the Java™ programming language to facilitate communications with Java™ clients using Java™ sockets. Java™ sockets are standard interprocess communication functional elements within the Java™ programming language and are well-known in the software arts to software engineers and designers who design and implement Java™ applications.

In accordance with the present invention, a Java™-to-Database Connectivity Server achieves connectivity between Java™ applications or applets and a standard database using an Applications

Programmer Interface (API) on the server side of a client/ server interface and an implementation of System Query Language (SQL) queries on the client side.

In accordance with one aspect of the present invention, a Java™-to-Database Connectivity Server supplies an interface between Java™ applications and database servers using an easy-to-use Java™ server Applications Programmer Interface (API) forming a uniform framework for building or integrating database connectivity across organizations and companies globally. The Java™ server API advantageously reduces the development time for interconnecting Java™ applications and applets with databases, accelerates the learning curve for operating the interface, and reducing training costs. A single API supplies connectivity with a database, for example, with Oracle or Sybase database servers, thereby simplifying the interconnection of a particular database. In some embodiments, the Java™-to-Database Connectivity Server is platform-independent and usable on any platform in any usage model (nomadic, remote access, Internet , and Intranet, for example). In some embodiments, the Java™-to-Database Connectivity Server is encoded entirely in the Java™ programming language using sockets and multi-threading, attaining the performance, safety, and security advantages of a Java™ system.

The Java™-to-Database Connectivity Server is used in Management Information Systems / Information Retrieval (MIS/IR) environments to connect networks to databases, thereby accelerating the migration of legacy software, new development programs, and software systems to Java™ and Web-enabled environments.

In accordance with an embodiment of the present invention, a server for attaching a Java™ application to a database includes a generic database server class having a database server instantiator with executable program code for instantiating instances of the database server, an instance of the database server class with a connection class constructor and a server socket creator, and a connection class instantiator with a server socket acceptor. The server also includes a generic connection class having an instance of the connection class with a database connection constructor and a socket stream creator, a creator of input and output socket streams, a creator of a database connection, a database connection including executable program code for database processing and data formatting of database information, and input and output socket streams including executable program code for transmitting the database information.

Many advantages are achieved by the described Java™-to-Database Connectivity Server system and operating method. One advantage is that the Java™-to-Database Connectivity Server supplies a universal API, thereby reducing the amount of coding and development time to allow communication of Java™ applications and applets with databases. Another advantage is that the Java™-to-Database Connectivity Server is predominantly implemented in the Server side of a Client/ Server interface, reducing the amount of application program development on the Client portion of the interface since the universal API is supplied as an interface, accelerating the learning curve for operating the interface, and reducing training costs.

It is advantageous that the server side of a client/ server interface is supplied by the Java™-to-Database Connectivity Server alone so that a user interface involves interactions with only a single set of software and hardware constructs. It is advantageous that the API resolves essentially all interfacing issues so that the Java™-to-Database Connectivity Server involves virtually no overhead for installation or usage. It is advantageous that both the client side and the server side of the interface are developed using the Java™ programming language so that the advantages of the Java™ language are attained on both sides of the interface.

It is advantageous that the Java™-to-Database Connectivity Server facilitates automation and software technology providing a framework for global standardization of business processes associated with Java™ applet/ application program development for accessing a relational database. The resulting standardized processes create a significant reduction in operational and development infrastructure advantageously promoting code sharing and reusability.

BRIEF DESCRIPTION OF DRAWINGS

The features of the described embodiments believed to be novel are specifically set forth in the appended claims. However, embodiments of the invention relating to both structure and method of operation, may best be understood by referring to the following description and accompanying drawings.

FIGURE 1 is a pictorial schematic block diagram showing a suitable communication environment for utilizing a Java™-to-Database Connectivity Server (JDCS).

FIGURE 2 is a flow chart illustrating operations performed by the JDCS.

FIGURE 3 is a schematic hierarchy diagram depicting various classes and methods in an embodiment of the JDCS implementing a Sybase server.

FIGURE 4 is a schematic data flow diagram illustrating an example of operations performed by the illustrative JDCS to search and retrieve information requested by the Java™ GUI from a relational database.

MODES FOR CARRYING OUT THE INVENTION

Referring to **FIGURE 1**, a pictorial schematic block diagram showing a suitable communication environment **150** for utilizing a Java™-to-Database Connectivity Server (JDCS) **100**. The JDCS **100** is a software interface between a database server **102** and Java™ programs, including applications and applets. The JDCS **100** typically and most usefully supports communications of Java™ applications and applets executing on a Java™ Graphical User Interface (GUI) **106** platform through a network **104** to the database server **102**. The Java™ GUI **106** and the JDCS **100** are associated in a client/ server relationship in which the Java™ GUI **106** is a client process executing on a computer system **110** that exchanges data via a

communication stream, such as a network **104**, with the Java™ Server **108**, a server process executing on another computer, for example a Web server **112**.

An illustrative communication environment **150** includes the computer system **110** connected to a database server **102** through the network **104**, the Web server **112**, and an Applications Programmer Interface (API) **114**. The computer system **110**, illustratively a personal computer, a desktop computer, a laptop computer, a workstation or the like, executes Java™ applications and applets in conjunction with the Java™ GUI **106**. Typically, the Java™ GUI **106** is encoded in the SpecJava™ programming language and environment, version 0.3-E. SpecJava™ is a GUI builder which generates Java code based on a Java™ Abstract Windowing Toolkit (AWT) toolset.

The network **104** is generic configuration of data processing devices and software connected for the exchange of information including various public and private networks. Suitable networks include Internet, Intranet or local area networks. For a local network, the JDCS **100** is contained in the same network as the application or applet. The Web server **112** is a hardware network interface server for executing software including a Java™ Server **108** and Java™ socket-level communications **116**. Typically, client and server software including the Java™ Server **108** and the Java™ socket-level communications **116** are encoded in the Java™ programming language and environment, version 1.0. Both client and server applications are developed using Java™ as the programming language and using the Java Developer's Kit 1.0 to compile the program code. The Java™ Server **108** and the Java™ socket-level communications **116** are constrained to execute on the Web server **112** under operating standards placed on Java™ browser programs, such as Netscape, which evoke a security violation in response to an attempt to execute from an unauthorized device.

The database server **102** is a conventional database server which is available from various vendors. Database servers include, for example, an Oracle database server (Version 7.3) and a Sybase database server (System 11). The API **114** is a generic relational database API for communicating with the database server **102**. The API **114** is vendor-independent and includes a plurality of vendor-specific API sections including, for example, an Oracle API section for communicating with an Oracle database server and a Sybase API section for communicating with a Sybase database server. Generally, the API **114** is a standard Applications Programmer Interface which is used by Java™-to-Database-Connectivity-Server application without modification. The Java™ Server **108** communicates with the API **114** using standard Java™ libraries which implement a native method of calling C++ programming language routines. The Oracle database server and the Sybase database server execute using a set of C++ libraries that are compatible with the Java™ libraries so that data communication between the Java™ Server **108** and the API **114** is facilitated.

In the illustrative embodiment, the JDCS **100** supports communication between the Java™ GUI **106** and the database server **102** using a communication protocol that is based on Java™ sockets, the Java™ socket-level communications **116** for executing by the Web server **112**. In other embodiments, interprocess communication methods other than socket methods may be used. Java socket methods in accordance with the

Java Developers Kit (JDK) 1.0 java.net class hierarchies are used to establish communication between client and server. The JDCS **100** uses a generic relational database for communications between the Java™ GUI **106** and the database server **102**.

The JDCS **100** performs low-level communication using sockets. A socket is an abstraction of an input file or an output file which is accessed using standard input and output file operations while communications are accomplished to a remote socket in a remote location via the network. Java™ socket-level communications **116** are established by programming which defines a java.net.ServerSocket class. In general, socket communications are established using a "listener" process (typically a main() program) which spawns threads to service the needs of a client process. By spawning threads, a plurality of which may be active at one time, the main() routine returns to a "listening" state while a thread is executing. The JDCS **100** uses the ServerSocket class to accept connections from clients. When a client connects to a communication terminal upon which a ServerSocket is "listening", the ServerSocket allocates a new Socket object which is connected to a new terminal to achieve Client communications. The server then returns to a "listening" operation to detect subsequent Client requests.

Referring to **FIGURE 2** in conjunction with **FIGURE 1**, a flow chart illustrates operations performed by the JDCS **100**. The JDCS **100** manages communications between the Java™ GUI **106** and the database server **102** based upon the usage of Java™ socket-level communications **116** and usage of a generic relational database API **114** to communicate to the database server **102**.

Java™ application codes and applets executing on the computer system **110** in conjunction with the Java™ GUI **106** examine the state of the client/ user interface in an operation **202**, interact with the database server in operation **204** to access a new form state, and transmit the new form state in operation **206** to the Java™ application or applet which originated the client request. The Java™ application codes and applets examine the state of the client/ user interface by parsing the data command, determining the System Query Language (SQL) command and arguments to be transferred. The form state is the data as a collection of attributes and values, arranged in rows and columns, that is accessed from a database.

The JDCS **100** models the state of the form as a collection of named attributes and values. One example of a typical attribute is a GUI widget. The value of the GUI widget represents the current form state of the widget. The JDCS **100** also mutually updates the model at the direction of the Java™ GUI **106** and updates the Java™ GUI **106** when the model is changed by the database server **102**.

The named attributes and values are updated based on an event-driven model and therefore occur in real-time. The JDCS **100** accommodates field-based events as well as form-based events.

The operation **204** of interacting with the database server to access a new form state utilizes a client communication module **210** for transmitting the state of the model in operation **212** to the database server **102** and receiving updates in operation **214** from the database server **102**. In operation **216**, the client

communication module **210** also reflects the state between the Java™ GUI **106** and the database server **102** on each client/ server interaction.

Referring to **FIGURE 3**, a schematic hierarchy diagram **300** depicts various classes and methods in an embodiment of the JDCS **100** implementing a Sybase server. The Sybase server is illustrative of a suitable database for accessing using the JDCS **100**. Other databases may also be used, including an Oracle database, for example. In the illustrative embodiment, the relational database model is based on a single-master repository with geo-specific replicated, distributed database servers in a three-tier client/server implementation. Other suitable database models that are known in the information systems art may be utilized in other embodiments.

The JDCS **100** includes two classes for the specific example of a Sybase server (sybServer). A first class is a Class new_sybServer **302**, and a second class is a Class Connection **304**.

The Class new_sybServer **302** is a generic class containing main driver routines for Sybase applications. Methods in the Class new_sybServer **302** perform operations including creating a server socket, and initiating a thread for socket communication and database connections. Methods defined for the Class new_sybServer **302** include a main() method **306**, a new_sybServer() method **308** and a run() method **310**. The main() method **306** is a "listening" process which instantiates instances of the Class new_sybServer **302** thereby spawning threads for performing a plurality of communication streams in parallel. The main() method **306** instantiates the Class new_sybServer **302**, a database server, so that the main() method **306** may be termed a "database server instantiator".

The new_sybServer() method **308** is a class constructor of the Class Connection **304** for creating a server socket and calling the run() method **310**. The run() method **310** accepts the socket connection and instantiates the Class Connection **304**. Several variables are defined for the Class new_sybServer **302** including a Sybjava variable "dbproc" for defining database connections, a ServerSocket variable "s" for defining a server socket which is used in a currently executing program, and a sockIO variable "sio" which is used to instantiate a sockIO class interface.

The Class Connection **304** is a generic class that performs essentially all communication management operations of the JDCS **100**. The Class Connection **304** contains all methods that are used for database processing, data formatting, and transmitting data from the database server **102** to the client Java™ GUI **106**. Methods defined for the Class Connection **304** include a Connection() method **312**, a getSockStreams() method **314**, a dbConnect() method **316**, and an otherResult() method **318**. The Connection() method **312** is a Class constructor that instantiates instances of the Class Connection **304** and establishes a database connection as directed by the Java™ GUI **106**, creates a socket stream, and calls the run() method **310**. The Connection() method **312** creates a socket stream and may be termed a "server socket creator" or "server interprocess communication creator".

The getSockStreams() method **314** creates input and output socket streams. The dbConnect() method **316** creates a Sybase database connection. The otherResult() method **318** notifies the client Java™ GUI **106** when a database transaction has failed. for any reason. Several variables are defined for the Class Connection **304** including a String variable "debug" for holding a character string assigned to a command line argument "DEBUG", a String variable "uid" for holding a character string designating a database user ID, a String variable "srv" for holding a character string designating a database server name, a String variable "db" for holding a character string designating a Sybase database name, and a String variable "app" for holding a character string assigning an internal name to an application. Additional variables defined for the Class Connection **304** include a String variable "inf" for holding a character string designating a directory path to the Sybase interfaces file, a Socket variable "so" identifying a socket used for the class within which the "so" variable is defined, and a Sybjava variable "dbproc" for defining database connections. Other variables defined for the Class Connection **304** include a String variable "qry" designating a character string for storing System Query Language (SQL) queries, a String variable "inputLine" designating a character string for storing a line of input read from the socket stream, a StringBuffer array "inBuf" designating a buffer storage for storing all lines read from the socket stream, and a String variable "sendrec" designating a character string for storing a formatted string record that is sent to the client Java™ GUI **106**. Further variables defined for the Class Connection **304** include a PrintStream variable "outS" which is assigned a handle of the output stream of a socket, a DataInputStream variable "sIn" which is assigned a handle of the input stream of a socket, a sockIO variable "sio" which is used to instantiate a sockIO class interface, and a Boolean variable "isDone" which is used as a completion flag for a thread delay loop.

Referring to **FIGURE 4**, a schematic data flow diagram illustrates an example of operations performed by the illustrative JDCS **100** to search and retrieve information requested by the Java™ GUI **106** from a relational database. In general, upon an occurrence of a defined event, a user initiates a request via the Java™ GUI **106** to extract data from a database, update data in the database or modify data in the database. The user sends a command via the Java™ GUI **106** using socket-level communications to the Java™-to-Database Connectivity Server. The command includes a SQL query that identifies the operation to be performed and arguments to the command. The Java™-to-Database Connectivity Server executes the requested database operation, generally a data retrieval or modification and returns extracted data to the Java™ GUI **106**. In the case of an error, such as a database error, an error status is returned from the database to the Java™ GUI **106**.

The JDCS **100** supplies an interface between client and server based on Java sockets which, in turn, utilize network protocols such as TCP/IP networking protocols. The TCP/IP protocol advantageously supports standard encryption technologies including data encryption standard (DES) and PGP (pretty good privacy). A client program sends SQL queries **402** to the server via the Java™ socket-level communications **116** interface. Each query is received by the server in the form of a socket connection **404**. The query is then submitted to the database server **102** via a database connection **416**. If any rows are transferred from the database server **102** to

the Java™ GUI **106**, the returned rows are processed sequentially and returned to the client via the socket interface.

The Java™ GUI **106** originates a System Query Language (SQL) query **402**, thereby issuing a command to the JDCS **100**. The SQL query is sent via socket connection **404** to the Class new_sybServer **302**. An illustrative SQL query is the command "exec get_db_info"25SERVEBay", 1", where the statement "25SERVEBay" is an identifier argument to the command and the number 1 is a flag argument to the command. The Class new_sybServer **302** begins execution of the main() method **306** which, in step **406**, calls the new_sybServer() method **308**. The main() method **306** "listens" for a command and is activated at the posting of the command by the Java™ GUI **106**.

The new_sybServer() method **308** creates a server socket **408** and calls the run() method **310** in step **410**. The run() method **310** accepts the socket connection **412** that is created in step **408** and instantiates the Class Connection **304** in step **414**. The run() method **310** instantiates the Class Connection **304** and may be termed a "connection class instantiator". The run() method **310** accepts the socket connection **412** and may be termed a "server socket acceptor". The Class new_sybServer **302** monitors to detect socket connections and, once a connection is established, the Class Connection **304** is instantiated.

The Class Connection **304** executes the Connection() method **312**, a class constructor which in step **416** creates a socket stream, constructs a database connection and calls the run() method **310**. The run() method **310** in the Class Connection **304** submits the SQL query to the database. In particular, the run() method **310** reads a line from the socket stream **418** and parses the line to determine which method to call **420**. Depending on the input line, an SQL query, the run() method **310** determines which method in the Class Connection **304** to invoke. The run() method **310** activates a database retrieve operation executing in the API **114**, retrieves data that is produced by the API **114**, formats the data, and writes the formatted data back to the Java™ GUI **106** via a return socket connection.

The run() method **310**, as directed by the SQL query, calls and executes a method **422** selected from among the methods of a getProjInfo() method **424**, an iudUtil() method **426**, a getPid() method **428**, a getStat() method **430**, and a getProjDetail() method **432**.

In general, the run() method **310** is an application server routine that updates the server's model of the form which is, in turn, transmitted back to the client by the server communication module. The application server routine normally does not invoke any client/ server interactions but simply facilitates the transfer of database information.

More specifically, when the selected method of the Class Connection **304** is called, the method is passed a string in the form of a SQL query. The run() method **310** submits the SQL query to the selected method in step **434**. The selected method processes incoming rows from the database. The selected method executes the SQL query **436**, thereby accessing or extracting designated columns and rows of the database.

The selected method stores selected columns into variables **438** for each row that is returned from the database. The selected method formats the retrieved columns **440** in accordance with a designation of the received SQL query and stores the retrieved columns in the form of a String. The selected method writes the formatted String to the socket output stream **442** and processes a next record by branching to step **436**. If the selected method detects a database error, in step **444** the method calls the otherResult() method **318**. The otherResult() method **318** displays any error message or processing status encountered while processing a user request. When the SQL query is satisfied, control is returned to the Java™ GUI **106**.

In the illustrative embodiment, the getProjInfo() method **424**, the iudUtil() method **426**, the getPid() method **428**, the getStat() method **430**, and the getProjDetail() method **432** are methods for retrieving information from a database. Generally, the differences between the illustrative methods is a difference in the number of columns extracted from the retrieved rows and the manner in which the columns are formatted for transmission to the client Java™ GUI **106**. Specifically, the getProjInfo() method **424** expects two columns per row retrieved. The iudUtil() method **426** executes an SQL query but expects no rows retrieved. The getPid() method **428** expects one column per row retrieved. The getStat() method **430** expects nine columns per row retrieved. The getProjDetail() method **432** expects ten columns per row retrieved. In addition to designating the number of columns to be retrieved, the information retrieval messages designate which rows are to be retrieved.

In the illustrative embodiment, a shell script (not shown) is used to automatically start the Class new_sybServer **302** when the Class new_sybServer **302** terminates execution for any reason. The shell script defines environmental variables including SYBASE, LD_LIBRARY_PATH and JAVA_HOME. SYBASE is a variable defining the directory path to interface files of Sybase. LD_LIBRARY_PATH is a variable defining the directory path to UNIX system's utility libraries. JAVA_HOME is a variable defining the Java software home directory path. A spotServer.sh script (not shown) may be invoked in the startup script of any system during rebooting so that Class new_sybServer **302** is available for execution at the time of system startup.

While the invention has been described with reference to various embodiments, it will be understood that these embodiments are illustrative and that the scope of the invention is not limited to them. Many variations, modifications, additions and improvements of the embodiments described are possible. For example, although the Java™-to-Database Connectivity Server is explicitly described as communicating with Sybase and Oracle databases, other databases are applicable to Java™ interfacing.

Furthermore, the illustrative embodiment shows a Web server **112** which is connected directly to a database server **102** in a local network. In other embodiments, the Web server **112** and the database server **102** may be connected via a network such as Internet, Intranet or local area networks. Accordingly, the JDCS **100** supports many different topology/ usage models including remote/ nomadic access models as well as standard connected access models.

Although the illustrative embodiment shows named attributes and values that are updated based on form-based events, updating based on field-based events is also supported.

Accordingly, the present invention is defined solely by the claims which follow and their full range of equivalents.

WE CLAIM:

1. A server (100) system for connecting an application to a database comprising:
program code defining a generic database server type (102) including:
a database server instantiator (306) including executable program code for instantiating instances of the database server type;
an instance of the database server type including a connection type constructor (308) and a server interprocess communication creator (312); and
a connection type instantiator including a server interprocess communication acceptor (412); and
program code defining a generic connection type including:
an instance of the connection type including a database connection constructor (416) and a interprocess communication stream creator.

2. A database communication system for connecting to a database server comprising:
a computer system (110) including executable program code implementing an application or applet;
a communication stream (104) coupled to the computer system;
a database server (102) coupled to the computer system via the communication stream including executable program code implementing a server for communicating data between the computer system and the database server using interprocess communication level communication; and
an Applications Programmer Interface (API) (114) coupled to the database server.

3. A database communication system according to Claim 2, wherein the executable program code implementing a server further comprises:
a generic database server type (102) including:
a database server instantiator (306) including executable program code for instantiating instances of the database server;
an instance of the database server type including a connection type constructor (308) and a server interprocess communication creator (312); and
a connection type instantiator including a server interprocess communication acceptor (412);
a generic connection type including:
an instance of the connection type including a database connection constructor (416) and a interprocess communication stream creator.

4. A method of connecting an application or applet to a database comprising:
instantiating an instance of a database server type to form a database server;

constructing a connection type by the operation of the database server;
creating a server interprocess communication handler by the operation of the database server;
instantiating the connection type to form an interprocess communication acceptor;
accepting the server interprocess communication by the operation of the interprocess communication acceptor;
instantiating the connection type to form a generic connection instance;
constructing a database connection by the operation of the generic connection instance; and
creating a interprocess communication stream by the operation of the generic connection instance.

5. A method of providing server for connecting an application or applet to a database comprising:
providing a generic database server type including:
a database server instantiator including executable program code for instantiating instances of the database server;
an instance of the database server type including a connection type constructor and a server interprocess communication creator; and
a connection type instantiator including a server interprocess communication acceptor; and
providing a generic connection type including:
an instance of the connection type including a database connection constructor and a interprocess communication stream creator;
a creator of input and output interprocess communication streams;
a creator of a database connection;
a database connection including executable program code for database processing and data formatting of database information; and
input and output interprocess communication streams including executable program code for transmitting the database information.

6. A method of providing a database communication system for connecting with a database server comprising:
providing a computer system including executable program code implementing an application or applet;
providing a communication stream coupled to the computer system;
providing a Web server coupled to the computer system via the communication stream including executable program code implementing a server for communicating data between the computer system and the database server using interprocess communication level communication; and
providing an Applications Programmer Interface (API) coupled to the Web server.

7. A computer program product comprising:
a computer usable medium having computable readable code embodied therein including a server for connecting an application or applet to a database including:
a generic database server type including:
a database server instantiator including executable program code for instantiating instances of the database server;
an instance of the database server type including a connection type constructor and a server interprocess communication creator; and
a connection type instantiator including a server interprocess communication acceptor; and
a generic connection type including:
an instance of the connection type including a database connection constructor and a interprocess communication stream creator;
a creator of input and output interprocess communication streams;
a creator of a database connection;
a database connection including executable program code for database processing and data formatting of database information; and
input and output interprocess communication streams including executable program code for transmitting the database information.

8. A system according to any of Claims 1, 2 or 3, further comprising:
an Applications Programmer Interface (API) (114) coupled to the input and output interprocess communication streams and coupled to a database, wherein:
the input and output interprocess communication streams communicate a database query to the API;
the API further includes:
executable program code for executing the database query;
executable program code for storing entries in a first dimension into variables for entries in a second dimension of data that are received from the database;
executable program code for formatting retrieved entries in the first dimension and storing the retrieved entries in the first dimension as a string; and
executable program code for writing the formatted string to the interprocess communication output stream.

9. A system according to either Claim 1 or Claim 3, wherein the generic connection type further includes:
a creator (314) of input and output interprocess communication streams;
a creator (318) of a database connection;

a database connection including executable program code for database processing and data formatting of database information; and

input and output interprocess communication streams including executable program code for transmitting the database information.

10. A system according to either Claim 1 or Claim 3, further comprising:

a interprocess communication level communication input connection coupled to the database server instantiator, the interprocess communication level communication input connection for carrying a database query, the database server instantiator being activated by a database query.

11. A system according to either Claim 8 or Claim 10, wherein:

the database query is a System Query Language (SQL) query.

12. A system according to any of Claims 1, 2, and 10, wherein:

the application is a Java™ application that is programmed in a Java™ programming language using a Java™ development system and installed for execution on a network server; and

the interprocess communication level communication input connection is coupled to a Java™ Graphical Users Interface (GUI) (106).

13. A system according to either Claim 1 or Claim 3, further comprising:

an Applications Programmer Interface (API) coupled to the input and output interprocess communication streams and coupled to a database, the API being selected from a group of APIs including:

a Sybase database connection API; and

an Oracle database connection API.

14. A system according to either Claim 1 or Claim 2, wherein:

the server is executable program code that is installed for execution on a Web Server.

15. A system according to either Claim 1 or Claim 2, wherein:

the server interprocess communication creator is a server socket creator using socket-level communications; and

the server interprocess communication acceptor is a server socket creator.

16. A method according to Claim 4 further comprising:

creating an input interprocess communication stream and an output interprocess communication stream; and

creating a database connection for connection to the input interprocess communication stream and the output interprocess communication stream.

17. A method according to Claim 16 wherein creating a database connection further includes:
processing the database through the operation of the database connection;
formatting database information through the operation of the database connection; and
transmitting the database information via the input interprocess communication stream and the output interprocess communication stream.

18. A method according to Claim 4, further comprising:
receiving a database query; and
instantiating a new instance of a database server upon receipt of the database query.

19. A method according to Claim 4, wherein the database connection is connected via an Applications Programmer Interface (API), the API performing the steps of:
receiving a SQL query;
executing the SQL query in response to receipt of the SQL query;
storing entries of the SQL query in a first dimension into variables for entries of a second dimension of data that are received from the database;
formatting retrieved entries in the first dimension and storing the retrieved entries in the first dimension as a string; and
writing the formatted string to the interprocess communication output stream.

20. A method according to Claim 4, wherein:
the method steps are implemented as a server in executable program code that is programmed in a Java™ programming language using a Java™ development system.

21. A method according to Claim 6 further comprising:
providing executable program code implementing a server including:
providing a generic database server type including:
a database server instantiator including executable program code for instantiating instances of the database server;
an instance of the database server type including a connection type constructor and a server interprocess communication creator; and
a connection type instantiator including a server interprocess communication acceptor; and
providing a generic connection type including:

an instance of the connection type including a database connection constructor and a interprocess communication stream creator;

a creator of input and output interprocess communication streams;

a creator of a database connection;

a database connection including executable program code for database processing and data formatting of database information; and

input and output interprocess communication streams including executable program code for transmitting the database information.

22. A computer program product according to Claim 7 wherein the computable readable code is encoded in a machine-readable form.

23. A computer program product according to Claim 7 wherein the computable readable code is encoded in a human-intelligible form that is convertible into a machine-readable form.

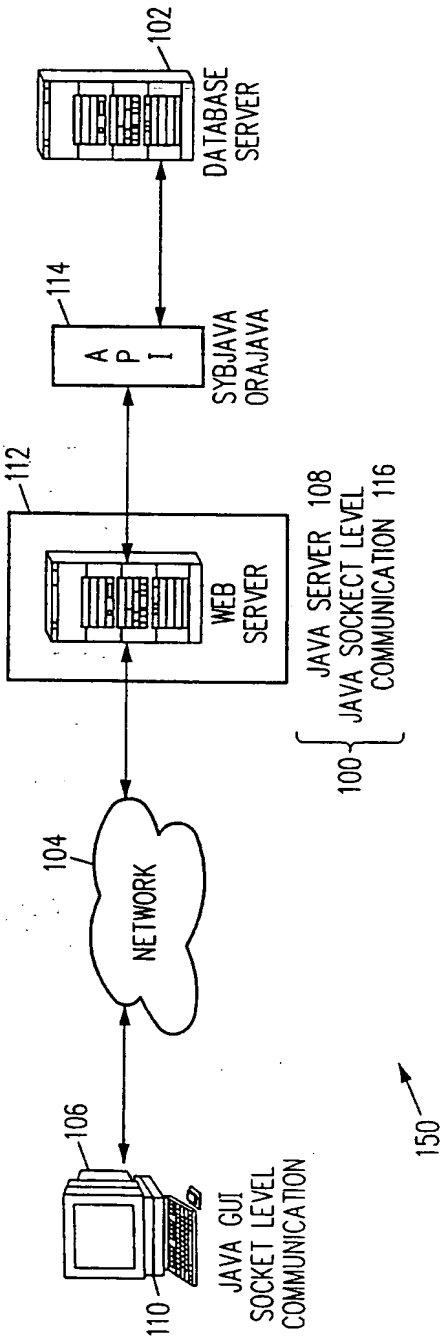

102
DATABASE SERVER
114
A P I
SYBJAVA ORAJAVA
112
WEB SERVER
JAVA SERVER 108
JAVA SOCKECT LEVEL COMMUNICATION 116
100
104
NETWORK
106
110
JAVA GUI SOCKET LEVEL COMMUNICATION
150

FIG. 1

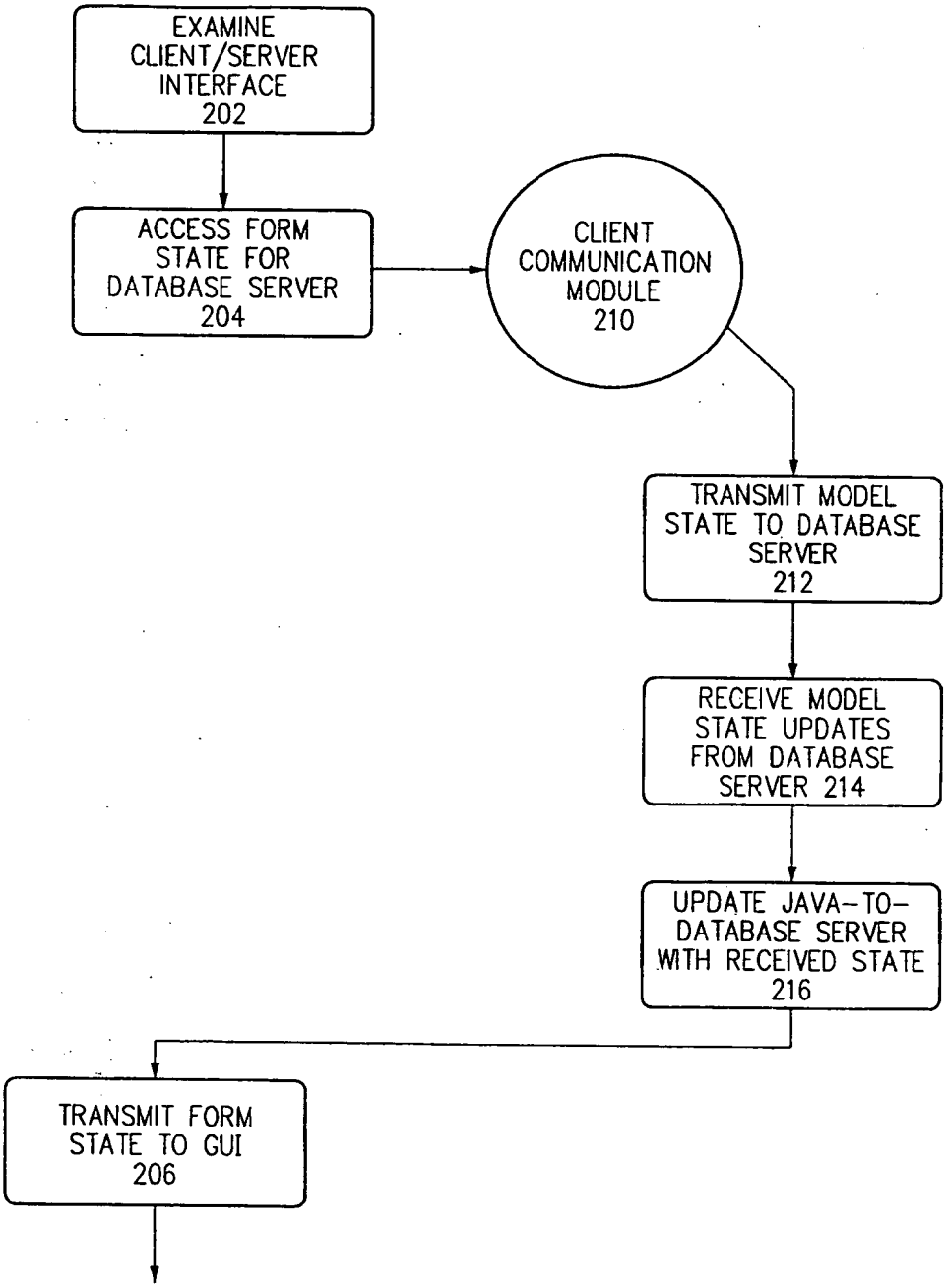

EXAMINE CLIENT/SERVER INTERFACE 202
ACCESS FORM STATE FOR DATABASE SERVER 204
CLIENT COMMUNICATION MODULE 210
TRANSMIT MODEL STATE TO DATABASE SERVER 212
RECEIVE MODEL STATE UPDATES FROM DATABASE SERVER 214
UPDATE JAVA-TO-DATABASE SERVER WITH RECEIVED STATE 216
TRANSMIT FORM STATE TO GUI 206

FIG. 2

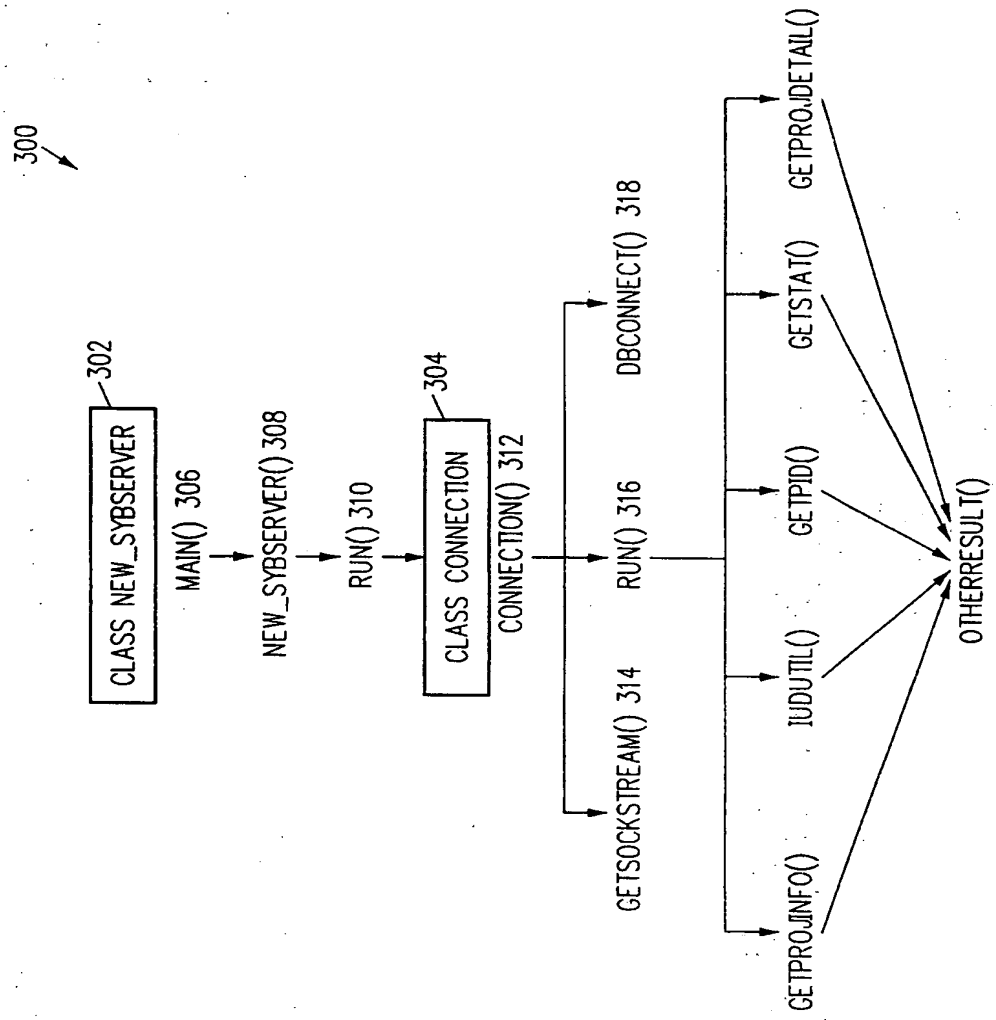
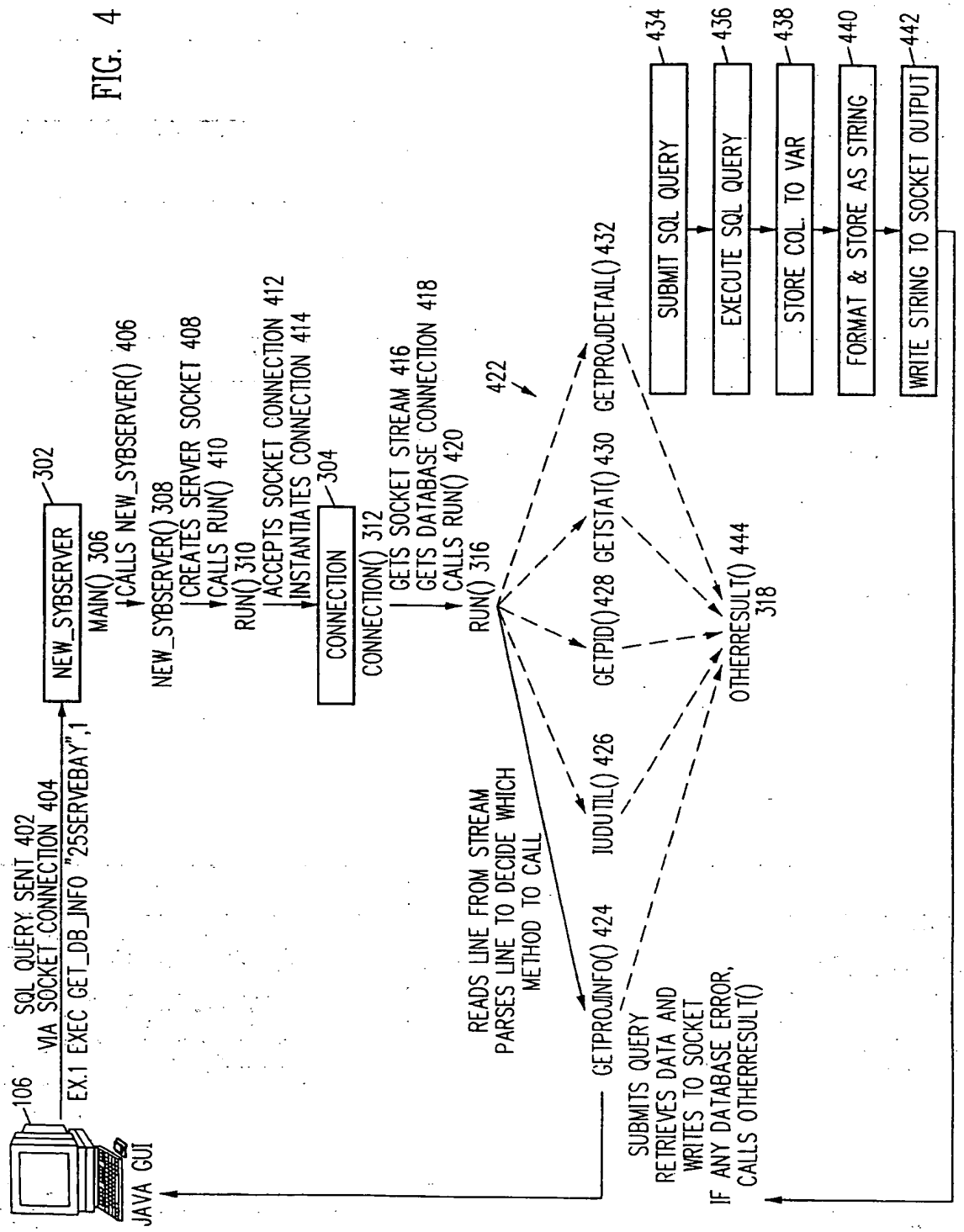

300
302
CLASS NEW_SYBSERVER
MAIN() 306
NEW_SYBSERVER() 308
RUN() 310
304
CLASS CONNECTION
CONNECTION() 312
DBCONNECT() 318
RUN() 316
GETSOCKSTREAM() 314
GETPROJDETAIL()
GETSTAT()
GETPID()
IUDUTIL()
GETPROJINFO()
OTHERRESULT()

FIG. 3

FIG. 4


106
JAVA GUI
SQL QUERY SENT 402
VIA SOCKET CONNECTION 404
EX.1 EXEC GET_DB_INFO "25SERVEBAY",1
NEW_SYBSERVER
302
MAIN() 306
CALLS NEW_SYBSERVER() 406
NEW_SYBSERVER() 308
CREATES SERVER SOCKET 408
CALLS RUN() 410
RUN() 310
ACCEPTS SOCKET CONNECTION 412
INSTANTIATES CONNECTION 414
CONNECTION
304
CONNECTION() 312
GETS SOCKET STREAM 416
GETS DATABASE CONNECTION 418
CALLS RUN() 420
RUN() 316
422
READS LINE FROM STREAM
PARSES LINE TO DECIDE WHICH
METHOD TO CALL
GETPROJINFO() 424
IUDUTIL() 426
GETPID() 428
GETSTAT() 430
GETPROJDETAIL() 432
SUBMIT SQL QUERY
434
EXECUTE SQL QUERY
436
STORE COL. TO VAR
438
FORMAT & STORE AS STRING
440
WRITE STRING TO SOCKET OUTPUT
442
OTHERRESULT() 444
318
SUBMITS QUERY
RETRIEVES DATA AND
WRITES TO SOCKET
IF ANY DATABASE ERROR,
CALLS OTHERRESULT()

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 98/06399

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06F17/30

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DUAN N N: "Distributed database access in a corporate environment using Java" COMPUTER NETWORKS AND ISDN SYSTEMS, vol. 28, no. 11, May 1996, page 1149-1156 XP004018216 see the whole document ---	1-23
X	"JDBC Guide: Getting Started" 6 March 1997 , SUN MICROSYSTEMS , INTERNET XP002069529 http://java.sun.com/products/jdk/1.1/docs/guide/jdbc/getstart/introTOC.doc.html , printed on 25 June 1998 Chapter 1, 2, 3 and 4 -----	1-23

☐ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 June 1998	16/07/1998

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